REDUCING IATROGENIC HYPOGLYCEMIA IN HYPERKALEMIC PATIENTS TREATED WITH INSULIN THERAPY WITH A MODIFIED HYPERKALEMIA ORDER SET AT THE QUEEN'S MEDICAL CENTER

A DOCTOR OF NURSING PRACTICE PROJECT SUBMITTED TO THE OFFICE OF GRADUATE EDUCATION OF THE UNIVERSITY OF HAWAI`I AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Abstract

Iatrogenic hypoglycemia as a result of hyperkalemia treatment is a common and potentially lethal complication. People with renal impairment are at an increased risk for hyperkalemia and hypoglycemia due to a decrease in glomerular filtration rate. During 2017, there were 87 episodes of hypoglycemia associated with hyperkalemia treatment at The Queen's Medical Center. The Academic Center for Excellence Star Model of Knowledge Transformation was used as the conceptual framework for the development of a standardized order set for providers and nurses that was implemented throughout The Queen's Health Systems to reduce hypoglycemic episodes during hospitalization for hyperkalemia treatment.

The target population was patients admitted and treated for hyperkalemia with insulin and dextrose and the percentage that had a hypoglycemic event within six hours of insulin administration. Methods to evaluate outcomes were based on data reports and manual electronic medical record review and analysis. This new hyperkalemia order set replaced the current hyperkalemia order set in the EPIC/Care*Link systems and medication administration record, which included more efficient and timely blood glucose checks. The new order set was successfully implemented on October 06, 2018.

Data was collected for two months, and during this period, 19 episodes of hypoglycemia were identified, and 14 treatments were implemented using the new order set. In comparison to the 12 month data, the number of hypoglycemic episodes increased slightly from 17% to 22%. In the two-month data collection period, provider participation for computerized hyperkalemia order set entry increased by 11%, from 62% in calendar year 2017 to 73%. Although, not a formal objective in this project, the time differences for blood glucose checks and identification of hypoglycemia incidences observed between order set and non-order set driven treatment were

noted. Order set driven treatments that were used precisely and correctly as indicated in the revised protocol in the two months' time frame showed efficient identification and treatments of hypoglycemia.

Introduction

Chronic Kidney Disease (CKD) continues to be an ongoing and prevalent issue in the United States affecting approximately 14% of the general population, often putting them at risk for multiple comorbidities, including electrolyte imbalances (National Institute of Diabetes and Digestive and Kidney Disease [NIDDKD], 2016). The kidneys are essential for the regulation of fluids, electrolytes, and acid-base balances. A decrease in glomerular filtration rate (GFR) associated with CKD can cause disturbances in electrolytes including potassium, phosphate, magnesium, and sodium homeostasis (Dhondup & Qian, 2017). An increase in potassium levels, or hyperkalemia, is one of the most dangerous electrolyte abnormalities, as it causes life threatening cardiac arrhythmias (Kovesdy, 2014). Hyperkalemia is defined by the National Kidney Foundation (NKF) as serum potassium greater than 5.0 mEq/L (2017). Current treatment for hyperkalemia includes the use of insulin plus glucose/dextrose to shift excess serum potassium intracellularly (Kovesdy, 2014). The American Heart Association treatment guidelines includes an infusion mixture of 25 g of glucose and 10 units of insulin, infused over 15 to 30 minutes for acute hyperkalemia treatment (Vanden Hoek et al., 2010). Although dextrose and insulin are the gold standard treatment of acute hyperkalemia, unfortunately, there are many reported incidences of hypoglycemia.

Hypoglycemia, defined as blood glucose (BG) below 70 mg/dL, is a common and sometimes lethal complication of hyperkalemia treatment. This is primarily due to a decrease in renal clearance of insulin and reduction in gluconeogenesis (Apel, Reutrakul, & Baldwin, 2014; NIDDKD, 2016). In a retrospective study conducted in a large academic medical center emergency department in Chicago, Illinois, hypoglycemia occurred in 13.1 to 24.6% in patients with renal impairment who were given intravenous (IV) insulin with dextrose for hyperkalemia treatment (LaRue, Peksa, & Shah, 2017). If left untreated, hypoglycemia, can lead to neurogenic and neuroglycopenic symptoms (Service, Cryer, & Vella, 2017). Neurogenic symptoms include pallor, tremors, palpitations, anxiety, diaphoresis, and paresthesia, while neuroglycopenic symptoms include psychomotor abnormalities, cognitive impairment, behavioral changes, seizures, coma, and even death (Service et al., 2017).

Description of Problem/Need

Currently, the hyperkalemia order set at The Queen's Medical Center (QMC) includes 10 units of regular insulin with IV bolus of 25-50 g of dextrose 50% (D50) (QMC, 2012). Blood glucose checks are ordered every two hours (Q2H) for eight hours (QMC, 2012). A retrospective chart review was conducted during a 12-month period (January-December 2017) with the following inclusion criteria: potassium level >5.0 mEq/L, administration of IV regular insulin, any degree of renal impairment, and a hypoglycemic event within six hours of insulin administration. Within this time period, 503 occurrences of IV insulin administration with the sole intent to treat hyperkalemia were identified. Of these 503 occurrences, 87 (17%) resulted in hypoglycemia, BG <70 mg/dL. Electronic Medical Records (EMR) were analyzed for electrophysiological changes associated with hyperkalemia, treatment for hyperkalemia, time from treatment to hypoglycemic episode, and BG values measured (with the focus on hypoglycemic episode value), and glomerular filtration rate (GFR). Many of these cases were identified during transfer from the emergency room to a hospital unit. GFR values for these patients ranged from 3-26 mL/min/1.73 m2, indicating severe decrease in kidney function for 81 of the identified 87 patients. Reported hypoglycemic symptoms included lethargy, dizziness, headache, shortness of breath, restlessness, and weakness. Average time from insulin to hypoglycemia was 146 minutes, while average time of first BG check was about 100 minutes. It was also noted that providers were not ordering the current hyperkalemia order set, which contributed to the variability in treatment; out of 87 cases of hypoglycemia, only 54 (62%) were order set driven. The other providers were ordering insulin and dextrose individually at their discretion. The types of providers who treated these patients for hyperkalemia also varied, including: Emergency Department (ED) Physicians, Hospitalists, Anesthesiologists, Resident Physicians, Advance Practice Registered Nurses or Physician Assistants, Registered Nurses (RNs) who ordered for providers, and Surgeons. Of the 54 providers who ordered the hyperkalemia order set, 37 were ED physicians. Non-protocol treated patients did not have prompt BG checks and the order set did not populate in their medication administration record (MAR). Patients were at a greater risk for hypoglycemia due to inadequate monitoring of potassium and glucose levels.

Review of Literature

A systematic literature search in PubMed, CINAHL, and Cochrane databases was conducted. Search terms included “Hyperkalemia”, “hyperkalemia treatment”, “management of hyperkalemia”, “renal impairment”, “renal insufficiency”, “acute kidney injury”, “AKI”, “CKD”, “chronic kidney diseases”, “ESRD”, “end stage renal disease”, “hypoglycemia”, “insulin”. Search terms were searched individually and in conjunction using Boolean operators: “AND” and “OR”. MeSH terms with subheadings were also used to refine the search. The search was limited to 2005-2017 and resulted in 104 articles. Articles were excluded if the abstract did not discuss glucose plus insulin for hyperkalemia treatment in patients with renal impairment. Of the 104 articles, 18 articles met these inclusion criteria and were reviewed. Mosby’s Level of Evidence (LOE) was used to grade the evidence and assess internal validity (Melnyk, 2011). There are eight levels of literature rating, including “other” (see Appendix

A). The category of “other” includes quality performance improvement, literature reviews, and clinical practice guidelines. The overall quality and LOE was low and majority of the articles were graded level V or “other” consisting of retrospective reviews or descriptive studies, literature review articles, and two practice guidelines (Melnyk, 2011). The synthesis resulted in two systematic reviews, one randomized cross-over double-blind study, one observational study, and two consensus statement articles. Appendix C provides a summary of the articles reviewed and synthesized using Mosby’s LOE. The validity of these articles was also assessed and ranged from fair to good. All articles were judged to have no fatal flaws that invalidated the results and study design.

Evidence Summary

Hyperkalemia and Hyperkalemia protocol. Indications for hyperkalemia treatment can have a starting range from 5.0 mEq/L and above (Chothia, Halperin, Rensburg, Hassan, & Davids, 2014; Kovesdy, 2014; Kovesdy, 2015; LaRue et al., 2017; Pierce et al., 2015). In general, treatment for hyperkalemia included the administration of 10-20 units of insulin IV with 50-100 ml of D50 bolus, equivalent to 25-50 g of glucose (Harel & Kamel, 2016). However, the treatment of hyperkalemia varied by hospital institution and was at the attending providers’ discretion.

Development of hypoglycemia. Administration of 10 units of IV insulin with 25g of glucose as tested by Chothia et al. (2017) showed incidences of hypoglycemia which occurred within 60-90 minutes after insulin administration. In studies with a hyperkalemia protocol with 10 units of IV insulin with 25 g of glucose/dextrose, hypoglycemia developed at a median of two to three hours after insulin administration (Apel et al., 2014; Schafers, Naunheim, Vijayan, & Tobin, 2011).

Traditional insulin dosing. An 8.7% to 13.0% risk of hypoglycemia in renal impaired patients was reported by Apel et al. (2014) and Schafers et al. (2011). Hypoglycemia developed within a three-hour time window post-insulin administration, which should prompt close monitoring and BG measurements at baseline, one hour, and three hours post-insulin administration (Apel et al., 2014; Schafers, et al., 2011).

Application to DNP project

Based on the literature search and synthesis, there was a clear need for the development of a universal or standardized practice guideline for providers and nurses to use to reduce iatrogenic hypoglycemia. Although the literature review resulted in low LOE, it was clear that a modification to the current QMC hyperkalemia order set should include more frequent BG checks and administration of glucose in a timely and efficient manner.

Conceptual Framework

The Academic Center for Excellence (ACE) Star Model of Knowledge Transformation is the conceptual framework used for evidence-based practice (see Appendix B). This model focuses on translating evidence into practice by highlighting appropriate forms of evidence, reducing the volume of literature, and directly applying into care and decision making (Stevens, 2013). The ACE Star Model of Knowledge Transformation was an appropriate choice for an Evidenced Based Practice (EBP) project because it focuses on implementing and applying EBP evidence and clinical expertise to develop clinical-practice guidelines or practices to improve quality in healthcare.

PICO Question

Based on the aforementioned background and problem, the following PICO statement was created to guide this EBP project: Over two months, will a new Queen's Medical Center acute hyperkalemia order set (I) reduce hypoglycemic episodes by 25%, defined as BG <70 mg/dL (O) that is associated with hyperkalemia treatment in patients with renal impairment (P) compared to the current order set (C)?

Purpose/Goals/Aims

The purpose of this EBP was to reduce the incidence of hypoglycemia in patients treated with IV insulin for hyperkalemia across QMC's four campuses (Punchbowl, West O`ahu, Molokai General Hospital, and North Hawai`i Community Hospital). To achieve this, the current hyperkalemia order set was replaced with the new order set to include D50 IV push (IVP) accompanied by BG checks every one hour (Q1H) for three occurrences. Once implemented, the goal was to reeducate providers about the existing order set and to review the revisions (new order set). Once the order set was ordered by a provider, D50 IVP and BG checks for Q1H for three occurrences would automatically populate in the MAR. In addition, nurses and ancillary staff were educated regarding the newly integrated hyperkalemia order set by checking blood glucose levels as indicated in the MAR. Another goal of this Doctor of Nursing Practice (DNP) project was to increase provider participation by 50% and uniformity in hyperkalemia treatment by ordering and using this modified hyperkalemia order set. However, the primary objective was to decrease hypoglycemic episodes by 25% in patients treated for hyperkalemia using insulin and dextrose.

Methods/Procedures

EBP is a "problem solving approach to clinical decision making in a healthcare organization that integrates the best available scientific evidence with the best available experiential (patient and practitioner) evidence, considers internal and external influences on practice, and encourages critical thinking in the judicious application of such evidence to care of the individual patient, patient population, or system" (Dang & Dearholt, 2017, p. 4). The use of EBP was appropriate for this project as it ensures that clinical expertise in addition to supported systematic research and evidence are in alignment with patient values. The goal was to provide the best care for patients all the while upholding the bioethical principal of non-maleficence. Advantages of EBP include: improvement of patient outcomes and identification of opportunities for research, areas for improvement, and gaps in knowledge (Dang & Dearholt, 2017).

Project Design

Recommendations for change were indicated (see Appendix D and E) and based on recommendations from The QMC's Nursing Practice Council, Diabetes Care Committee, and The Medicine and Nutrition Committee. Appendix F outlines a simplified algorithm of interventions to prevent hypoglycemia which includes: immediate (STAT) BG check prior to insulin administration, blood glucose checks Q1H for three hours followed by glucose checks Q2H for four hours. Parameters for D50 administration were outlined to alert the medical staff of declining trends in BG before the threshold of hypoglycemia occurs.

This project was approved for implementation in March 2018 and the process of integration of the revised order set with Informatics/Care*Link team into the EMR began in late March of 2018. The end date for this DNP project was December 06, 2018. A Gantt chart shows the projected timeline (see Appendix G). Approvals were received from the following QMC committees, as needed for implementation of new hyperkalemia order set: Diabetes Care Committee, Medicine and Nutrition Committee, and Nurse Practice Council. A blueprint of the order set was also presented to the Care*Link team with the guidance of the nursing Informatics to ensure it will have the necessary components for EMR use. The hyperkalemia order set was reviewed on October 05, 2018 and successfully implemented into the EMR system on October

06, 2018. Information sessions and in services were completed with the ED staff which included RNs and nursing assistants in five sessions over two weeks; attendance ranged from 15-20 staff members. A presentation was done with ED providers and hospitalists prior to implementation, during the QMC's ED Hale Meeting in September 2018. In addition, the Information technology (IT) department also sent out a system wide bulletin notifying of the newly implemented order set. After implementation of the new order set in the EMR, data collection on the following criteria began immediately: number of patients admitted to QMC for hyperkalemia who received treatment for hyperkalemia and number of patients who became hypoglycemic (blood glucose <70 mg/dL) within six hours post hyperkalemia treatment. A data analysis report was requested from the IT department containing data requested based on the parameters specified and compared to the baseline data from calendar year 2017. Interpretation of the data report was done by manual EMR review.

Evaluation/Results

EMR Data was captured and reviewed over two months from October 06-December 06, 2018 (see Appendix H). During this time period, 87 occurrences of IV insulin administration for hyperkalemia treatment were identified. Of these 87 occurrences, 19 (22%) resulted in hypoglycemia. In terms of provider participation, all treatments were ordered by a physician (i.e., ED, resident, hospitalist), 14 (74%) of the 19 occurrences were order set driven and 5 (26%) of the 19 occurrences were based on individual provider orders. The average time from insulin to hypoglycemia for all 19 episodes was 155 ± 122 minutes. The average time from insulin administration to the first glucose check was 83 ± 88 minutes. Of 14 episodes that were order set driven, only five (36%) order sets were used correctly, precisely as indicated in the revised protocol, the average times from insulin to hypoglycemia were 162 ± 131 minutes and 97 ± 57 minutes, while the average times from insulin administration to the first glucose check were 58 ± 31 minutes for all 14 episodes and 53 ± 24 minutes for five episodes that had correctly used order sets, respectively (see footnote in Appendix H). The five of 19 episodes that were not order set driven, resulted in an average time of 136 ± 102 minutes from insulin administration to hypoglycemia and 152 ± 152 minutes for the first glucose check after insulin administration.

Limitations

A limitation of EBP for this project was the lack of available evidence or high LOE to meet the criteria of best available evidence. There was insufficient data regarding the prevalence of renal impairment and hypoglycemia that resulted from hyperkalemia treatment. In addition, no standard treatment protocol or algorithm for emergent acute hyperkalemia was identified. There was also an insufficient number of articles appropriate for evidence-based practices as noted with Mosby's Level I and II. Majority of the articles reviewed consisted of retrospective studies and review articles, which does not accurately depict cause-and-effect following an intervention.

Limitations of this project design included retrospective data review from 2017 which did not account for any interventions or universal protocol for hyperkalemia. In addition, implementation and integration of the revised hyperkalemia order including pre-intervention data collection and review took about 11 months. The order set could not be fully assimilated into the EMR without properly creating and programming it into the EMR system. There were also a series of reviews of the order set done by the Informatics team, which required additional editing of the order set blueprints. Instructions and in-service trainings on the new order set were provided only to the providers in the ED department at Queens.

Discussion/Conclusion

Although the primary and secondary objectives were not formally met, there was potential for satisfaction of objectives if given a similar timeframe to the comparison group. In comparison to the 12-month data, the number of hypoglycemic episodes increased slightly from 17% to 22%. Over only a two month data collection period, providers' use of the computerized hyperkalemia order set entry increased by 11%, from 62% in calendar year 2017 to 73%. Although, not a formal objective in this project, the time differences observed between order set and non-order set driven treatment were noted. Collectively, the average time from insulin to hypoglycemia increased from 146 minutes to 155 minutes when compared to year 2017. When divided into subgroups, the average times from insulin to hypoglycemia for the 14 order set driven treatment, the five correctly used order set driven treatments and the give non-order set driven treatments, the times were 162 minutes, 97 minutes, and 136 minutes, respectively. The average time from insulin administration and hypoglycemia were expected to decrease as glucose checks promoted efficient treatment for hypoglycemia. Although, the time increased from the collective total and order set driven total, the five order sets that were used correctly showed a decrease of 49 minutes in average time when compared to 146 minutes in 2017. Collectively, the average time from insulin to the first glucose checked compared to year 2017 decreased from 100 minutes to 83 minutes. While the average time from insulin to the first glucose check for the 14 order set driven treatments was 58 minutes; the average time for the five correctly used order set driven treatments was 53 minutes; and the average time for the five non-order set driven treatments was 152 minutes, respectively. The average time for the first glucose check was expected to decrease as glucose checks were scheduled to be done every hour for three occurrences. Data concluded that the average times decreased for all episodes related to the order set driven treatments when compared to non-order set driven treatments.

The use of the order set was also screened for completeness. Only five of the 14 order sets were used as indicated from the modified provisions in the new order set; the remaining nine treatments did not complete the order set. Reasons for incompleteness include: omitted Q1H blood glucose checks, missed Q1H checks at the third occurrence, opted-out of follow-up orders for dextrose and glucose checks, and missed administration of dextrose. Providers had the option to opt-out of follow-up orders by unchecking a box in the EMR system, which includes dextrose administration orders and Q1H checks for three occurrences.

This project had several barriers. First, the integration of this new order set into the QHS EMR system required more time than expected. As a result, only two months of data were collected for the results compared to the baseline data with 12 months. Secondly, the sheer quantity of episodes in comparison to 2017 were also limited and may not reflect an accurate portrayal of the impact of this revised hyperkalemia order set. Thirdly, the primary department that was targeted for this project was the emergency department. This department was chosen strategically as majority of the hyperkalemia treatments were initiated in the ED. Data was collected from all departments in the 12-months in 2017 and two months in 2018. However, only the ED received formal training and educational sessions post-implementation of the new hyperkalemia order set. Although, a system wide bulletin was sent to all staff notifying of the new order set, targeted interventions and educational sessions were not done for other departments.

Facilitators of this project include communication, managerial and peer support, availability of data and time to review data, and opportunities for training. The implementation of this new hyperkalemia order set was possible with the guidance and views of various disciplines, which addressed potential obstacles from every level. Communication between departments was also a key factor to ensure timely responses for the design and integration of the order set into the EMR. Availability of data and reports were also dependent upon effective communication to ensure that the data and reports requested were precisely what was needed for data collection. In addition, availability of time was integral to review patient records and the reports received.

DNP Essentials

The American Association of Colleges of Nursing created 8 Essentials listed in *The Essentials of Doctoral Education for Advanced Nursing* to "address the foundational competencies that are core to all advanced nursing practice roles" (American Association of Colleges of Nursing [AACN], 2006, p. 8). The DNP degree focuses on "practice that is innovative and evidence-based, reflecting the application of credible research findings" (AACN, 2006, p. 3). The following paragraphs will describe how this EBP project aligns and integrates with specific AACN essential competencies.

Essential I: Scientific Underpinnings for Practice. This essential focuses on integrating extensive nursing science and knowledge to create a strong foundation congruent with nursing values and practice to improve health care delivery. This project used knowledge from a several areas of expertise including: clinical practice guidelines, healthcare systems, research, and scientific principles to identify and develop a standardized protocol that could address the needs of an at-risk clinical population.

Essential II: Organizational and Systems Leadership. This essential "emphasizes practice, ongoing improvement of health outcomes, and ensuring patient safety" (AACN, 2006,

p. 10). This DNP project attempted to assess the practice policies and strategies needed to balance productivity and quality of care to develop a sustainable hyperkalemia clinical set of orders at both the organizational and systems level. In addition, cost-effectiveness and risks of this EBP project intervention were considered and implemented with realistic and effective designs and strategies. Organizational, political, cultural, and economic perspectives were pertinent to ensure patient safety and quality of care upholding communication and collaboration.

Essential III: Clinical Scholarship and Analytical Methods for EBP. The application of this competency focuses beyond research and scholarship and involves connecting and integrating knowledge, science, and human nature across disciplines and diverse sources. Clinical scholarship and analytical methods of EBP involves "translation of research into practice and the dissemination and integration of new knowledge" (AACN, 2006, p.11). The primary goal of this DNP project focused on improving health outcomes of high risk patients. The revised hyperkalemia order set was created using the best available research and practice guidelines that was translated into practice while promoting safe, timely, efficient, equitable patient centered care (AACN, 2006, p.11).

Essential IV: Information Systems and Technology. This essential highlight the use information systems and technology to improve patient care and systems. Specifically, "information systems/technology provide a mechanism to apply budget and productivity tools, practice information systems and decision supports, and web-based learning or intervention tools to support" (AACN, 2006, p. 13). This EBP project involved evaluating information systems and patient care technology to extract data, evaluate outcomes, provide leadership, and improve the use of information for clinical accuracy, timeliness, and appropriateness (AACN, 2006, p.

13). Understanding the EMR of the organization and collaborating with the IT department was essential to creating and integrating a revised hyperkalemia order set into the EMR system. In addition, data collection and analysis needed for pre and post interventions required proficiency and technical skills to evaluate data from the EMR and database.

Essential V: Health Care Policy for Advocacy in Healthcare. Health care policy "is created through governmental actions, institutional decision making, or organizational standards--creates a framework that can facilitate or impede the delivery of health care services or the ability of the provider to engage in practice to address health care needs (AACN, 2006, p. 13). The development of the intervention for this EBP project needed to align with the organization's policies and standards, including the mission and vision. The organization's policies and procedures were considered and followed to ensure development and implementation of the new order set was done professionally and appropriately. This project involved designing, executing and advocating a change in the internal health care policy to improve access to care, quality of care, and health care financing and to reduce health care disparities.

Essential VI: Interprofessional Collaboration. In order to fulfill the Institute of Medicine requirement "for safe, timely, effective, efficient, equitable, and patient-centered care in a complex environment, healthcare professionals must function as highly collaborative teams" (AACN, 2006, p. 14). Effective communication and multi-disciplinary collaboration were consistently practice during this EBP project. Collaboration with multi-disciplinary roles including physicians, nurses, nursing assistants, IT support and interprofessional teams (i.e., Medicine and Nutrition Committee, Diabetes Care Committee, Informatics, and ER department staff) were necessary to develop and implement of newly standardized protocol in health care delivery.

Essential VII: Clinical Prevention and Population Health. Clinical prevention is defined as "health promotion and risk reduction/illness prevention for individuals and families. Population health is defined to include aggregate, community, environmental/occupational, and cultural/socioeconomic dimensions of health" (AACN, 2006, p. 15). This project demonstrates clinical prevention and population health since the new hyperkalemia order set focuses on a population (i.e., patients with renal impairment, acute care/hospitalized patients) who are at risk for hyperkalemia and iatrogenic hypoglycemia. The intervention from this EBP project addressed health promotion, health status, and potential gaps in care with a new standardized order set that will benefit the population who are at the most risk.

Essential VIII: Advanced Nursing Practice. DNP programs provide the curriculum and foundational practices and skills needed to fulfill the growth of specialization in nursing. DNP graduates are "expected to demonstrate refined assessment skills and base practice on the application of biophysical, psychosocial, behavioral, sociopolitical, cultural, economic, and nursing science as appropriate in their area of specialization" (AACN, 2006, p. 16). As previously aforementioned, an adverse effect of hyperkalemia treatment was hypoglycemia. An adult-gerontology nurse practitioner with a diabetes educator certification with a specialize skills set to understand the complexities of potassium and glucose level management oversaw this project. The adult-gerontology DNP student designed, implemented, and evaluated an intervention utilizing clinical judgement and evidence-based research, while developing therapeutic relationships with other professionals to improve patient outcomes and optimize care. Meetings and educational in services helped guide and support other nurses and groups through the pre and post implementation of the intervention to achieve excellence in care.

Plans for Dissemination

The results will be shared through oral presentation and formal written report/publication. Results and feedback will be shared and gathered from staff members of the inpatient diabetes team and ED staff who were exposed and those who participated in the implementation of this new order set.

Summary

In summary, the five order sets that were used correctly and directly as indicated, although small, in the two months' time frame showed efficient identification and treatments of hypoglycemia. Future directions would be to continue to monitor the effects of the newly integrated hyperkalemia order set with the goal of reduction of hypoglycemia episodes. Other potential directions would be to gather data and feedback regarding the new order set from providers and address concerns and suggestion for improvements to the order set. It is also evident that more in services are needed to educate providers in other departments of the new order set and to understand reasonings of variations in orders and uses of the order set. Future implications would be to have this order set available to QHS system wide and potentially to serve as a model for health systems statewide.

References

American Association of Colleges of Nursing (AACN). (2006). The essentials of doctoral education for advanced nursing practice. Retrieved from https://www.aacnnursing.org/Portals/42/Publications/DNPEssentials.pdf

American Diabetes Association (ADA). (2016). Standards of medical care in diabetes—2017: summary of revisions. *Diabetes Care,* 40 (Supplement 1):S1-S135. doi:10.2337/dc17-s001

Apel, J., Reutrakul, S., & Baldwin, D. (2014). Hypoglycemia in the treatment of hyperkalemia with insulin in patients with end-stage renal disease. *Clinical Kidney Journal, 7*(3), 248-250. doi:10.1093/ckj/sfu026

Chothia, M., Halperin, M. L., Rensburg, M. A., Hassan, M. S., & Davids, M. R. (2014). Bolus administration of intravenous glucose in the treatment of hyperkalemia: A randomized controlled trial. *Nephron Physiology, 126*(1), 1-8. doi:10.1159/000358836

Coca, A., Valencia, A. L., Bustamante, J., Mendiluce, A., & Floege, J. (2017). Hypoglycemia following intravenous insulin plus glucose for hyperkalemia in patients with impaired renal function. *Plos One, 12*(2): e0172961. doi:10.1371/journal.pone.0172961

Dang, D., & Dearholt, S. (2017). *Johns Hopkins nursing evidence-based practice: models and guidelines.* 3rd ed. Indianapolis, IN: Sigma Theta Tau International.

Dhondup, T., & Qian, Q. (2017). Electrolyte and acid-base disorders in chronic kidney disease and End-Stage Kidney Failure. *Blood Purification, 43*(1-3), 179-188. doi:10.1159/000452725

Harel, Z., & Kamel, K. S. (2016). Optimal dose and method of administration of intravenous insulin in the management of emergency hyperkalemia: A systematic review. *Plos One, 11*(5): e0154963. doi:10.1371/journal.pone.0154963

Kim, Y., Rajan, K. B., Sims, S. A., Wroblewski, K. E., & Reutrakul, S. (2014). Impact of glycemic variability and hypoglycemia on adverse hospital outcomes in non-critically ill patients. *Diabetes Research & Clinical Practice*, *103*(3), 437-443. doi:10.1016/j.diabres.2013.11.026

Kovesdy, C. P. (2014). Management of hyperkalemia in chronic kidney disease. *Nature Reviews Nephrology, 10*(11), 653-662. doi:10.1038/nrneph.2014.168

Kovesdy, C. P. (2015). Management of hyperkalemia: An update for the Internist. *The American Journal of Medicine, 128*(12), 1281-1287. doi:10.1016/j.amjmed.2015.05.040

LaRue, H., Peksa, G. D., & Shah, S. (2017). A comparison of insulin doses for the treatment of hyperkalemia in patients with renal insufficiency. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, 37: 1516-1522. doi:10.1002/phar.2038

Mahoney, B. A., Smith, W. A., Lo, D., Tsoi, K., Tonelli, M., & Clase, C. (2005). Emergency interventions for hyperkalemia. *Cochrane Database of Systematic Reviews 2005*, Issue 2. Art. No.: CD003235. doi:10.1002/14651858.cd003235.pub2

McNicholas, B. A., Pham, M. H., Carli, K., Chen, C. H., Colobong-Smith, N., Anderson, A. E., & Pham, H. (2017). Treatment of hyperkalemia with a low-dose insulin protocol is effective and results in reduced hypoglycemia. *Kidney International Reports,* 3(2), 328-336. doi:10.1016/j.ekir.2017.10.009

Melnyk, B. M. (2011). *Evidence-based practice in nursing & healthcare: a guide to best practice* (2nd ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). (2016, August 01). *Low blood glucose (hypoglycemia).* Retrieved from https://www.niddk.nih.gov/health-information/diabetes/overview/preventing-problems/low-blood-glucose-hypoglycemia

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). (2016, December). *Kidney disease statistics for the United States.* Retrieved from https://www.niddk.nih.gov/health-information/health-statistics/kidney-disease

National Kidney Foundation (NKF). (2017, October 06). *Best practices in managing hyperkalemia in chronic kidney disease.* Retrieved from https://www.kidney.org/content/best-practices-managing-hyperkalemia-chronic-kidney-disease

National Kidney Foundation (NKF). (2016, March 24). *Clinical update on hyperkalemia: diagnosis, evaluation and treatment options for hyperkalemia in patients with CKD.* Retrieved from https://www.kidney.org/content/clinical-update-hyperkalemia-diagnosis-evaluation-and-treatment-options-hyperkalemia

National Kidney Foundation (NKF). (2017, April 4). *Facts about high potassium in patients with kidney disease.* Retrieved from https://www.kidney.org/atoz/content/hyperkalemia/facts

Pierce, D. A., Russell, G., & Pirkle, J. L. (2015). Incidence of hypoglycemia in patients with low eGFR treated with insulin and dextrose for hyperkalemia. *Annals of Pharmacotherapy, 49*(12), 1322-1326. doi:10.1177/1060028015607559

Raymond, C., Sood, A., & Wazny, L. (2010). Treatment of hyperkalemia in patients with chronic kidney disease -- a focus on medications. *CANNT Journal*, *20*(3), 49-54.

Rossignol, P., Legrand, M., Kosiborod, M., Hollenberg, S. M., Peacock, W. F., Emmett, M., Mebazaa, A. (2016). Emergency management of severe hyperkalemia: Guideline for best practice and opportunities for the future. *Pharmacological Research, 113*, 585-591. doi:10.1016/j.phrs.2016.09.039

The Queen's Medical Center (QMC). (2012). *Hyperkalemia management.* Retrieved from http://www.queens.org/CARE_Link2 /pharmacy/hyperkalemia.pdf

Vanden Hoek, T. L., Morrison, L. J., Shuster, M., Donnino, M., Sinz, E., Lavonas, E., Jeejeebhoy, F., Gabrielli, A. (2010). Part 12: Cardiac arrest in special situations: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation, 122*(S3). S829-61. doi:10.1161/circulationaha.110.971069

Schafers, S., Naunheim, R., Vijayan, A., & Tobin, G. (2011). Incidence of hypoglycemia following insulin-based acute stabilization of hyperkalemia treatment. *Journal of Hospital Medicine, 7*(3), 239-242. doi:10.1002/jhm.977

Service, F., Cryer, P., & Vella, A. (2017, March 14). *Hypoglycemia in adults: Clinical manifestations, definition, and causes.* Retrieved from http://www.uptodate.com/contents/hypoglycemia-in-adults-clinical-manifestations-definition-and-causes

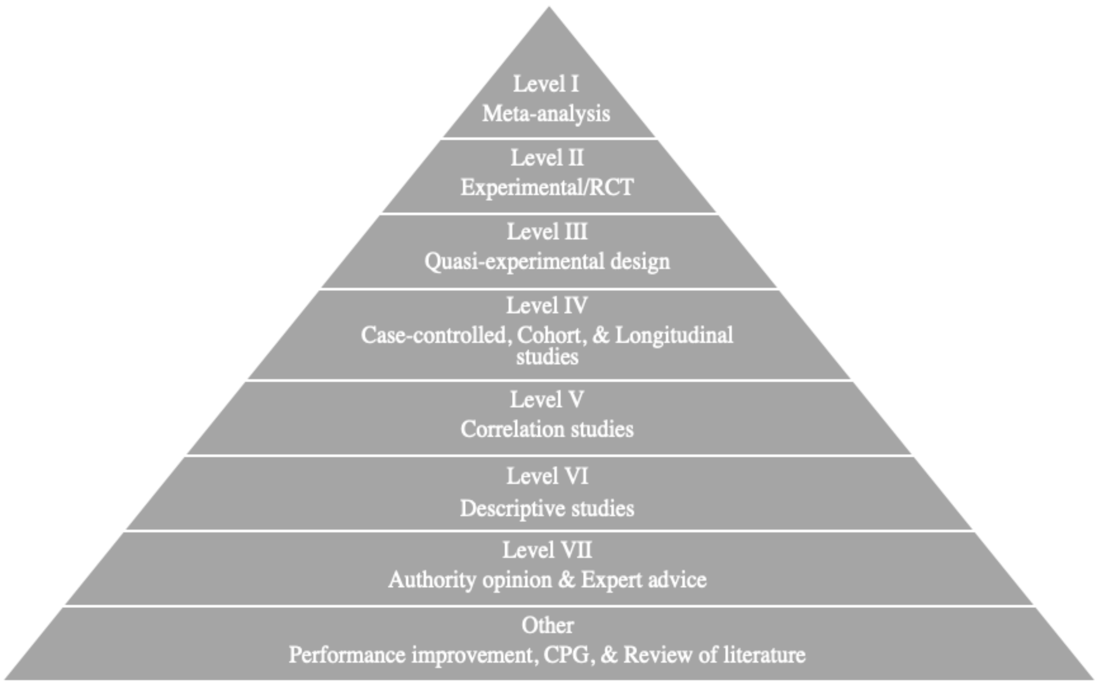
Sterns, R. H., Grieff, M., & Bernstein, P. L. (2016). Treatment of hyperkalemia: Something old, something new. *Kidney International, 89*(3), 546-554. doi:10.1016/j.kint.2015.11.018

Stevens, K. R. (2013). The impact of evidence-based practice in nursing and the next big ideas. *Online Journal Of Issues In Nursing*, *18*(2), 1. doi:10.3912/OJIN.Vol18No02Man04

Wheeler, D. T., Schafers, S. J., Horwedel, T. A., Deal, E. N., & Tobin, G. S. (2016). Weight-based insulin dosing for acute hyperkalemia results in less hypoglycemia. *Journal of Hospital Medicine, 11*(5), 355-357. doi:10.1002/jhm.254

Appendices

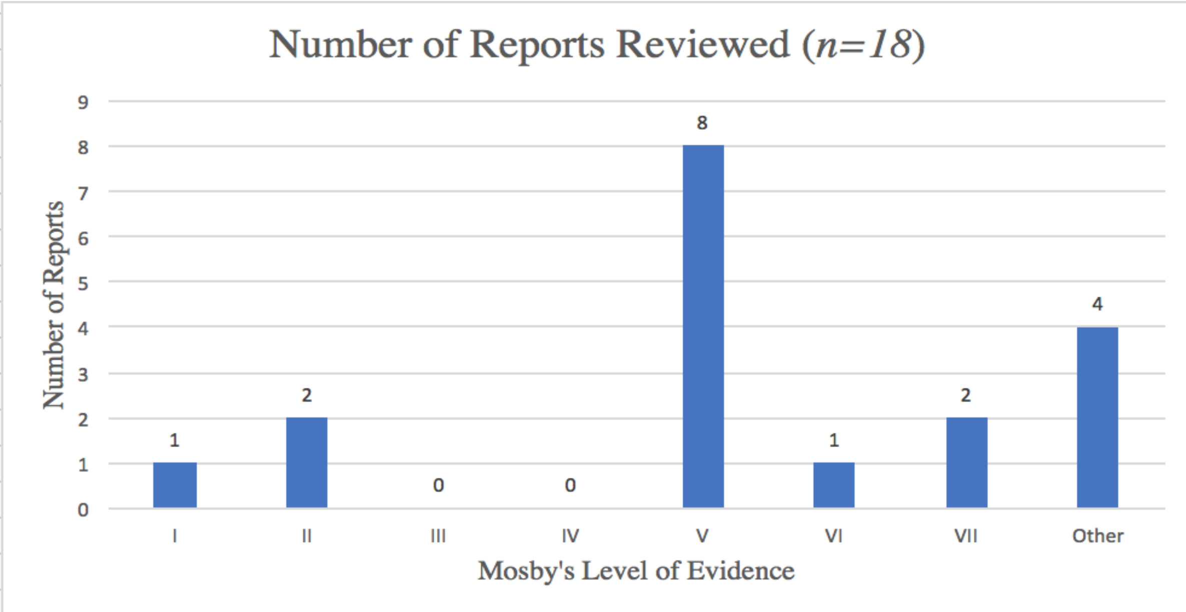
Appendix A: Mosby's Level of Evidence



Appendix B: ACE Star Model of Knowledge Transformation

1. Discovery: primary research studies.
2. Evidence Summary: synthesis of available knowledge and evidence
3. Translation into action: creation of recommendations and guidelines based on best clinical-practice evidence and clinical expertise
4. Integration: evidence-in-action, implementing change with evidence-based practice (EBP) project
5. Evaluation: reflection of overall change of EBP and effect of quality improvement.

Appendix C*:* Number of reports reviewed and synthesized using Mosby's Level of Evidence.



Appendix D: The Queen's Medical Center original hyperkalemia order set

HYPERKALEMIA MANAGEMENT [975]

MNC Guidelines

- Discontinue all potassium supplementation (oral, intravenous, parenteral nutrition).
- Discontinue medications that interfere with potassium excretion (e.g. ACEIs, NSAIDs, triamterene, spironolactone).
- Consider EMERGENT dialysis for patients with acute renal failure and refractory hyperkalemia or patients with acute renal failure and hyperkalemia with ECG changes (widening QRS, bradycardia, markedly prolonged QT, or peaked T-waves).

EKG - if potassium level greater than 6.0		
EKG, 12 Lead		ONCE, Starting today For 1 Occurrences Select Indications: OTHER-PLEASE SPECIFY Select patient's current CV medications: STAT
Notify MD		Notify MD if EKG abnormalities are present and obtain order for transfer to monitored bed, if appropriate.
Insulin Orders		
Initial Insulin and Dextrose Orders Panel (Hyperkalemia Protocol)		
	Regular Insulin 10 units IV Push	IV Push, INSULIN ONCE Starting today For 1 Doses, STAT Administer with 25-50 g of glucose (Hyperkalemia Protocol)
	Dextrose 50 % (D50W) 25 g IV Push	25 g, IV Push, ONCE For 1 Doses Administer slow IV Push (Hyperkalemia Protocol) STAT
	Dextrose 50 % (D50W) 50 g IV Push	50 g, IV Push, ONCE For 1 Doses Administer slow IV Push (Hyperkalemia Protocol) STAT
	Glucose Meter	Q2H (EVEN), Starting today For Until specified • Routine Notify MD if: For Inpatients, ED and CDU: Q2 hours for 8 hours. For Outpatients: Q2 hours for 4 hours. Initiate Adult Hypoglycemia Protocol, if needed. (Hyperkalemia Protocol)
	Potassium Level (2 hours after Insulin/Dextrose given)	PRN For 1 Occurrences Special Instructions to Lab (Do not use to request additional tests. Enter separate orders to request additional tests): Nursing to schedule 2 hours after Insulin/Dextrose boluses given (Hyperkalemia Protocol) Routine
Nursing		
Notify MD	Call MD if repeat potassium level is greater than 5.0 (Hyperkalemia Protocol)	
Transfer		
	Transfer to Telemetry	

Appendix E: Recommendations for changes/Proposed hyperkalemia order set

HYPERKALEMIA MANAGEMENT [975]

MNC Guidelines		
• Discontinue all potassium supplementation (oral, intravenous, parenteral nutrition). • Discontinue medications that interfere with potassium excretion (e.g. ACEIs, NSAIDs, triamterene, spironolactone). • Consider EMERGENT dialysis for patients with acute renal failure and refractory hyperkalemia or patients with acute renal failure and hyperkalemia with ECG changes (widening QRS, bradycardia, markedly prolonged QT, or peaked T-waves).		
EKG - if potassium level greater than 6.0		
EKG, 12 Lead		ONCE, Starting today For 1 Occurrences Select Indications: OTHER-PLEASE SPECIFY Select patient's current CV medications: STAT
Notify MD		Notify MD if EKG abnormalities are present and obtain order for transfer to monitored bed, if appropriate.
Insulin Orders		
Initial Insulin and Dextrose Orders Panel (Hyperkalemia Protocol)		
	Regular Insulin 10 units IV Push	IV Push, INSULIN ONCE Starting today For 1 Doses, STAT Administer with 25-50 g of glucose (Hyperkalemia Protocol)
	Dextrose 50 % (D50W) 25 g IV Push	25 g, IV Push, ONCE For 1 Doses If unable to obtain pre-treatment BG, administer 25g If pre-treatment BG > 100, administer 25 g of glucose If pre-treatment BG ≤ 100, administer 50 g of glucose Administer slow IV Push (Hyperkalemia Protocol) STAT
	Dextrose 50 % (D50W) 50 g IV Push	50 g, IV Push, ONCE For 1 Doses If unable to obtain pre-treatment BG, administer 25 g of glucose If pre-treatment BG > 100, administer 25 g of glucose If pre-treatment BG ≤ 100, administer 50 g of glucose Administer slow IV Push (Hyperkalemia Protocol) STAT
	Glucose Meter	Once, STAT (Hyperkalemia Protocol)
Follow-up Dextrose Orders (Hyperkalemia Protocol)		
	Dextrose 50% (D50W) 12.5-25 g IV Push	Administer 12.5-25g, IV Push Q1H, for 3 hours. To be started 1 hour after IV Push Insulin. Admin instructions: If BG 71-100 mg/dL: administer 12.5 g of glucose If BG ≤70 mg/dL: administer 25 g of glucose If BG ≤150 mg/dL and no contraindications, give patient 4 oz juice (no Orange juice for patients with ESRD) (Hyperkalemia Protocol)
	Glucose Meter	Q1H, for 3 hours. To be started after IV Push Insulin administration. Then, Q2H for 4 hours. (Hyperkalemia Protocol)
	Potassium Level (2 hours after Insulin/Dextrose given)	PRN For 1 Occurrences Special Instructions to Lab (Do not use to request additional tests. Enter separate orders to request additional tests): Nursing to schedule 2 hours after Insulin/Dextrose boluses given (Hyperkalemia Protocol) Routine
Nursing		
Notify MD	Call MD if repeat potassium level is greater than 6.0 (Hyperkalemia Protocol)	
Transfer		
	Transfer to Telemetry	

Key: [yellow box] recommendations/changes to the QMC Hyperkalemia Protocol

Appendix F: Hyperkalemia order set algorithm

Hyperkalemia Protocol/order-set activated

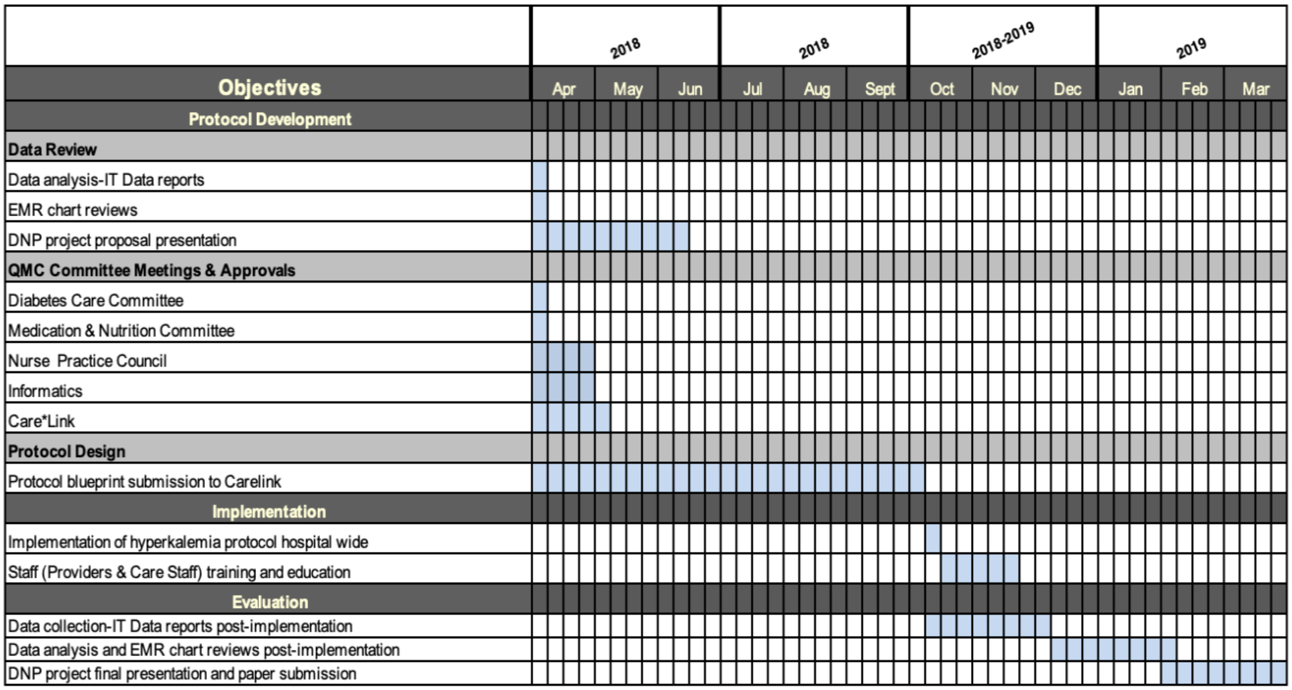
Check blood glucose STAT prior to administering Dextrose (D50)/Regular Insulin medications IV Push (IVP)

- Administer Dextrose/Regular Insulin IVP per provider's orders
- If patient has to be transferred to another unit or during another shift, communicate to oncoming staff that hyperkalemia treatment with insulin has been given

- Glucose meter: Q1H glucose checks for 3 hours
  - ❖ Start 1 hour after Dextrose/Regular Insulin IVP administration.
  - ❖ Notify MD, if BG trending <100 mg/dL.
- Administration instructions:
  - ❖ If BG 71-100 mg/dL: administer 12.5 g D50 IVP
  - ❖ If BG ≤ 70 mg/dL: administer 25 g D50 IVP
  - ❖ If BG ≤ 150 mg/dL and no contraindications exist: give patient 4 oz of juice (avoid orange juice with ESRD)

- After 3 hours, glucose meter: Q2H glucose checks for 4 hours.
- If BG 71-100 and no contraindications exist, give patient 4 oz juice (avoid orange juice with ESRD) and maintain vigilance monitoring for hypoglycemia.
- If BG ≤70, activate Hypoglycemia Protocol (674-xx-781-B)

Appendix G: Timeline



Appendix H: Results

	2017 (01/01/17-12/31/17)	**2018** (10/06/18-12/06/18)		
	Total	Total	Order set driven tx (14 of 19)*	Non-order set driven tx (5 of 19)
# of hyperkalemia incidences requiring treatment	503	87	-	-
# of hypoglycemia (BG <70 mg/dL) episodes	87	19	14	5
Average time from insulin dose to hypoglycemia episode	146 minutes	155 minutes	162 minutes	136 minutes
Average time from insulin dose to first glucose check	100 minutes	83 minutes	58 minutes	152 minutes

* 5 of 14 order set driven treatments were used correctly; average time from insulin dose to hypoglycemia episode 97 minutes and average time from insulin dose to first glucose check 53 minutes